EUROPEAN DEFENCE AGENCY

Fact sheet

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GREENMARK

Renewable & geothermal energy in modular architecture

AIRBUS A400M HANGAR – Seville military airbase, Spain

Why?

Permanent military bases and deployed camps suffer from a lack of autonomy for the generation of power and thermal energy, depending heavily on the use of fossil fuels to that purpose. The volatility in energy prices and, most importantly, the security issues and even loss of lives during the supply of fuel in hostile environments are pressing factors to save energy as much as possible and to reduce the uncertainty in planning for budget.

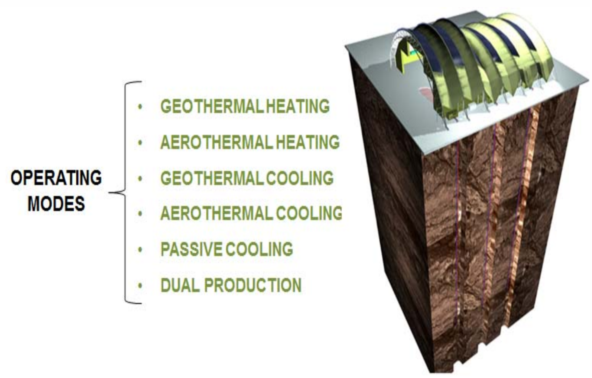
GREENMARK (Geothermal & Renewable Energy in Modular Architecture System) project aimed to develop a deployable and highly energy efficient modular architecture provided with renewable energy production technologies, both for military bases and rapid deployed operations in emergencies, humanitarian missions or natural disasters.

These missions require a self-sufficient and highly energy efficient system which is easily stored, transported, mounted and dismantled, and adaptable to different conditions around the world.

How?

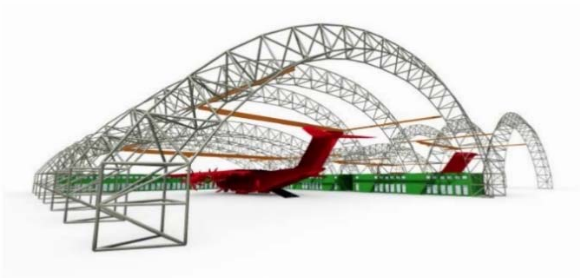
GREENMARK project consisted in the development and construction of a hangar at ***"La Maestranza"*** military airbase in Seville (Spain), and a modular technical demonstrator in the ***ITM (Instituto Técnico La Marañosa)***, in Madrid (Spain), under the auspices of the Spanish Ministries of Interior, Environment, Foreign Affairs, and Defence.

The aim was to demonstrate the viability and benefits of a more rapid construction system consisting of a highly energy efficient modular architecture supplied with renewable energy production technologies, mainly geothermal energy and aerothermal energy, for the provision of power, heating, cooling and domestic hot water (DHW) to the building, both for permanent and temporary installations, and bringing savings in energy consumption and costs, and gains in the missions' operability, scope and resilience.



This modular architecture design can be fully customised to fit different purposes; the structure can be easily stored, transported using standard ISO 20-feet containers for intermodal transport and/or air transport, assembled, disassembled and/or modified to adapt to different purposes, and requires minimum maintenance.

It is therefore a high technology state of the art solution, suitable for operations by both the defence sector, in permanent bases or deployed camps, and the private sector. Importantly, the investment can be amortised with the life cycle of the building.



AIRBUS A400M HANGAR – Seville military airbase, Spain

Applicability/ Replicability/ Scalability in the Defence sector

The modular structures may be used in temporary or permanent installations, both for military based operations and deployed military or humanitarian operations, providing an energy efficient solution that can be rapidly deployed, and easily and quickly installed, ensuring an uninterrupted autonomous renewable energy supply.

The modular architecture building system can be easily adapted to meet different needs and conditions in military bases (hangars, airport terminals, warehouses, hospitals, offices, accommodation and all kinds of civil infrastructures) and deployed camps (peace keeping and humanitarian missions, natural catastrophes, etc.).

HANGARS – Zaragoza military airbase, Spain

Modular architecture NZEB offices – Seville military airbase, Spain

Results

Heating 24 hours a day of a building of 200 m² during 60 days in winter, heating with geothermal energy.	
Energy Delivered in Heating (kWh)	15000
Energy Delivered in Hot Water (kWh)	1220
Hot Water at 45°C (Litre)	30000
Energy Consumption (kWh)	3031
COP	5,35
Consumed Fuel Gallons	396
Producing Energy Economic Cost	21384
Price in kWh $	1,32

Average fuel gallon price on campaign at $ 54
Electric Generation by means of a generating set with a yield of 20%

Heating 24 hours a day of a building of 200 m² during 60 days in winter, heating with Aerothermal energy.	
Energy Delivered in Heating (kWh)	15000
Energy Delivered in Hot Water (kWh)	1220
Hot Water at 45°C (Litre)	30000
Energy Consumption (kWh)	3557
COP	4,56
Consumed Fuel Gallons	465
Producing Energy Economic Cost	25110
Price in kWh $	1,55

Average fuel gallon price on campaign at $ 54
Electric Generation by means of a generating set with a yield of 20%

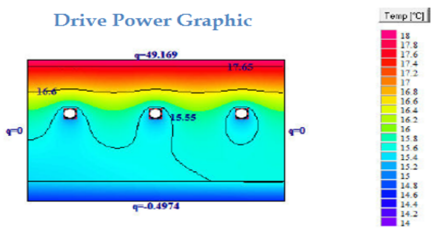
Heating - SLIP 24 hours aida of a building of 200 m² during 60 days in winter. Heating - Hot Water - Thermoelectric	
Energy Delivered in Heating (kWh)	15000
Energy Delivered in Hot Water (kWh)	1220
Hot Water at 45°C (Litre)	30000
Energy Consumption (kWh)	17075
COP	0,95
Consumed Fuel Gallons	2231
Producing Energy Economic Cost	120474
Price in kWh $	7,43

Average fuel gallon price on campaign at $ 54
Electric Generation by means of a generating set with a yield of 20%

Heating Results Table

Drive Temperature (°C)	Temperature imp-ret (°C)	Average Floor Temperature (°C)	Power Output (W/m²)
45	42,5	32,3	147,74

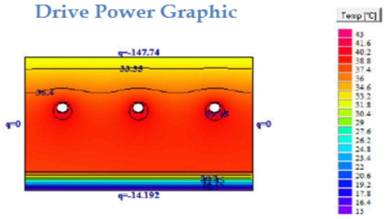
Drive Power Graphic



Refrigeration Results Table

Drive Temperature (°C)	Temperature imp-ret (°C)	Average Floor Temperature (°C)	Power Output (W/m²)
12	14,5	17,98	49,17

Drive Power Graphic



Benefits

This innovative modular architecture system allows to obtain all the advantages of a "traditional building" but with much shorter manufacturing lead and assembly times, for a highly competitive price, and without detriment to the expected energy performance, whether the building is permanent or temporary.

This sort of infrastructure reduces energy consumption, and consequently, the need for supply of fossil fuels which, in remote or dangerous locations, results in increased resilience and autonomy of the mission.

Other benefits are:

- o Lower weight per area unit (energy saving when transporting). The use of structural aluminium with similar resistance to the steel, 2,600 kg/cm^2 in aluminium 2086 T6 versus 2,750 kg/cm^2 of steel but 3 times lighter, allows for transport by air which means economic savings from fast and effective installations.
- o Reduction of the primary energy needed for the supply of generators, production base equipment for the supply of HVAC and ACS in all types of infrastructures.
- o Reduction of budgets for supply of fossil fuels.
- o Easy assembly requiring very few people, resulting in further energy savings derived from the transportation and accommodation of people while assembling it (A/C, purification, services, kitchen, etc.)
- o Easy installation, requiring little training of staff, which reduces times and costs for qualification of personnel, and few machinery and tools.
- o Efficient installations (low consumption lighting system).
- o Efficient water management.
- o Simplicity and durability of installations.

Challenges

The main challenges this project faced were the achievement of:

- o The necessary levels of flexibility in the design to adapt to different needs.
- o Quick manufacturing lead and implementation times.
- o The necessary levels of modularity for easy storage, transportation, mounting and dismounting.
- o Compliance with applicable construction regulations and security constraints of the defence sector.
- o Significant efficiency performance.
- o Integration of renewable energies.
- o Minimal maintenance requirements.
- o Durability, economy, maintainability and environmental sustainability from throughout its whole life cycle.
- o Required comfort levels.

Opportunities

- o Integration of a wider variety of energy efficiency, generation, monitoring and management technologies into the system, to optimise the power consumption and comfort conditions even further.
- o Further reductions in energy consumption and need for fossil fuels in favour of greater autonomy and reduced vulnerability in operations, as well as cost savings.
- o Improvement of thermal insulation of the infrastructure to increase the energy performance rate and reduce the thermal footprint, minimise traceability of the building through infrared night vision systems.

Latest update: 23.10.2017